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DISCONNECT SWITCH GENERATED TRANSIENT VOLTAGES ON MAGNETIC PT WIRING AT CECIL TS

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Magnetic PTs at Cecil TS are an early design that does not incorporate an interwinding electrostatic shield. Measurements show that operation of the 115-kV gas-insulated disconnect switches in the station can produce moderate to high transient voltages on the PT secondary wiring. Transient protection will be required if solid-state relays are installed in this station.

INTRODUCTION

Magnetic Potential Transformers (PTs) of the type used at Cecil TS, a new 115 kV gas-insulated substation in downtown Toronto, do not have interwinding electrostatic shields. Such shields are used in most modern designs to reduce high-frequency transient coupling between the high-voltage primary side and the low-voltage secondary circuit. Following some Research Division tests/1/ showing that transient voltages on the secondary winding could be as high as 10 kV during disconnect-switch operations, a request was received from Equipment and Materials Department/2/ for on-site measurements to be made during station soak tests.

MEASUREMENT PROCEDURE

At the time of the tests, the ring bus at Cecil TS was energised from Charles TS through line L9C and line disconnect 49-L9C (Figure 1). Measurements were made on the red phase, B protection, secondary wiring of potential transformer 49L9CVT during the operation of line disconnect 49-L9C and the disconnects for breakers HL9, L5L9, L5L6, and PL6.

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Some measurements were also made on transformer 49H8LCVT during the operation of disconnects for breaker L7L8. This transformer had no secondary wiring installed.

Transient voltages were measured at the PT terminals with a digital fast-transient data acquisition system using a passive 1000:1 50-ohm voltage divider probe. Transient voltages and cable shield currents at the relay-room cable termination were measured with a model 5210 Microinstruments peak-reading transient voltmeter and a clip-on wide-band current probe connected to a Tek 465 oscilloscope.

TRANSIENT VOLTAGE MAGNITUDES

The highest transient voltages are produced by the operation of line disconnects directly proximal to the PT under observation. This result is to be expected due to the absence of any power-splitting bus junctions between the line disconnect and the PT. Breaker disconnects are always separated by at least one junction and produce transient voltages a factor of two or more lower. Analysis of the test data shows that peak transient voltages produced on PT secondary wiring at Cecil TS by line disconnect operations wil be in the ranges given in Table 1. A typical voltage transient is shown in Figure 2.

Table 1

Transient Voltages on PT Secondary Wiring at Cecil TS

PT secondary terminals - 49H8LCVT, open circuit	3 kV
PT secondary terminals - 49L9CVT, cable attached	3 kV
Cable Termination - open circuit	
short shield ground strap*	800 V
long shield ground strap	1200 V
Cable Termination - relay load	
short shield ground strap	400 V
long shield ground strap	600 V

*Shield ground straps may range from about 10 to 60 cm in length.

DISCUSSION

The Cecil TS data confirm the previous finding that moderate to high transient voltages may occur on the secondary wiring of these unshielded PTs. Following are some specific comments on the data:

(i) One would normally expect the open-circuit voltage at PT terminals to be higher than the voltage with a cable connected. The open-circuit voltage measured in these tests, at the terminals of transformer 49H8LCVT, may be affected by the presence of a second PT temporarily connected in parallel with 49H8LCVT in place of a voltage arrestor. However, this possibility could not be confirmed in the present tests.

(ii) The PT secondary wiring is routed through a cable marshalling panel in one of the breaker modules. Transient voltages at the relay-room cable termination will therefore be reduced, relative to the voltages that would be measured with an unbroken cable run, as a result of the cable interconnections made at this panel.

(iii) Transient voltages on open-circuit cables may exceed existing guidelines (500 V) for the installation of solid-state protective relaying or other electronic equipment. Guidelines are not exceeded when the cables are connected to the presently installed electromechanical relays and shield ground straps are less than 30 cm in length.

(iv) Cable shield currents at the relay-room termination are relatively high at up to 12 A peak and contribute to the transient voltage through ground strap coupling. This confirms the need to keep cable-shield ground straps as short as possible.

(v) The main frequency components in the transient voltages are in the range from 7 to 12 mHz. This agrees with previous findings/3/ that frequencies are typically an order of magnitude higher in GIS than in conventional substations and are therefore outside the range of frequencies included in the Ontario Hydro transient immunity test/4/.

CONCLUSIONS

Transient voltages on PT secondary wiring at Cecil TS will be moderate to high, by present standards, being up to 3 kV peak at the PT terminals and 600 volts peak across the electromechanical relay loads. The voltages are due in part to capacitive coupling between primary and secondary windings in the transformer resulting from the absence of an interwinding electrostatic shield and in part, depending on ground-strap length, to ground-strap coupling resulting from shield currents. Shield ground straps (green wires) should be checked to ensure that they do not exceed 30 cm in length. No further remedial action is considered necessary as long as electromechanical relays are connected to the PT cables, but the installation of fast-acting transient suppressors should be considered if solid-state relays are fitted at a future date.

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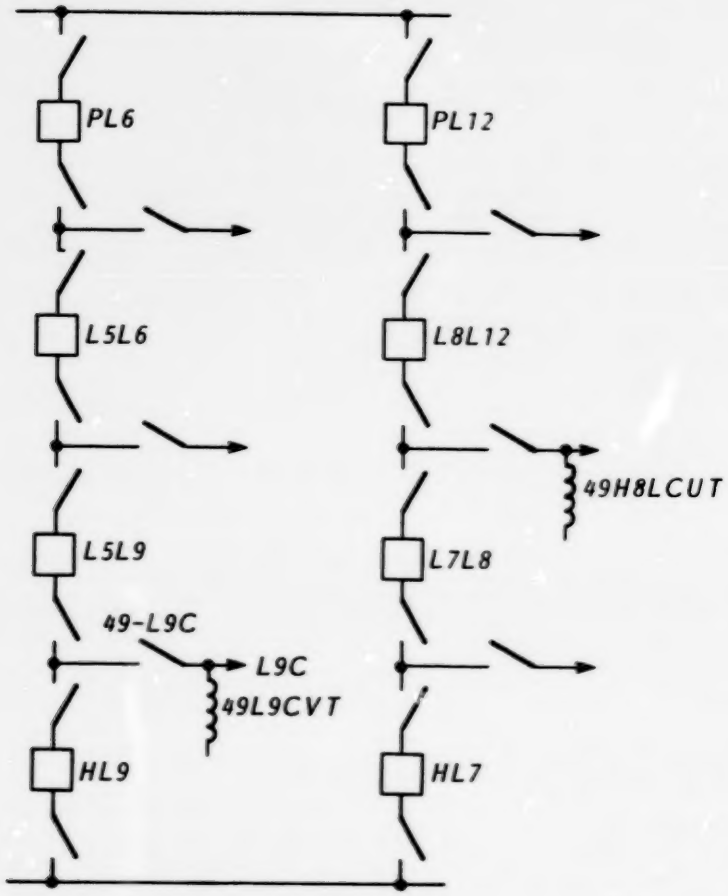
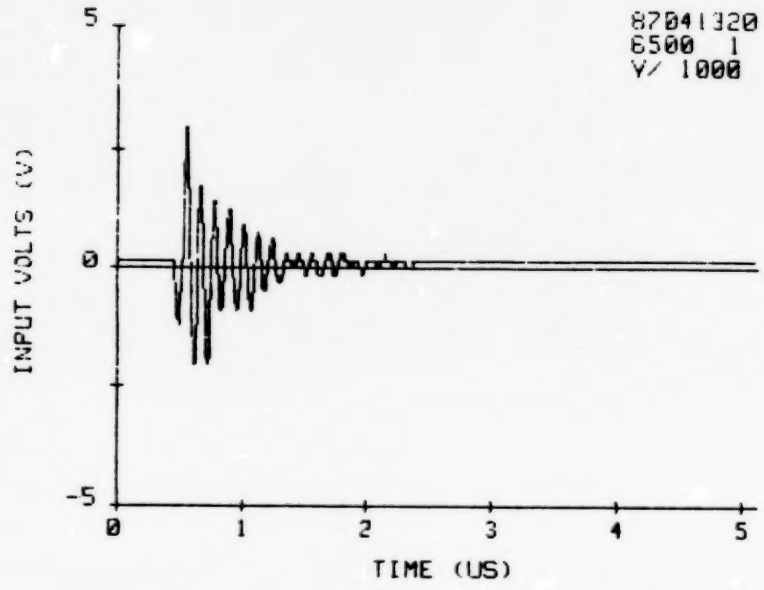


FIGURE 1

SIMPLIFIED 115 kV RING-BUS SCHEMATIC, CECIL TS



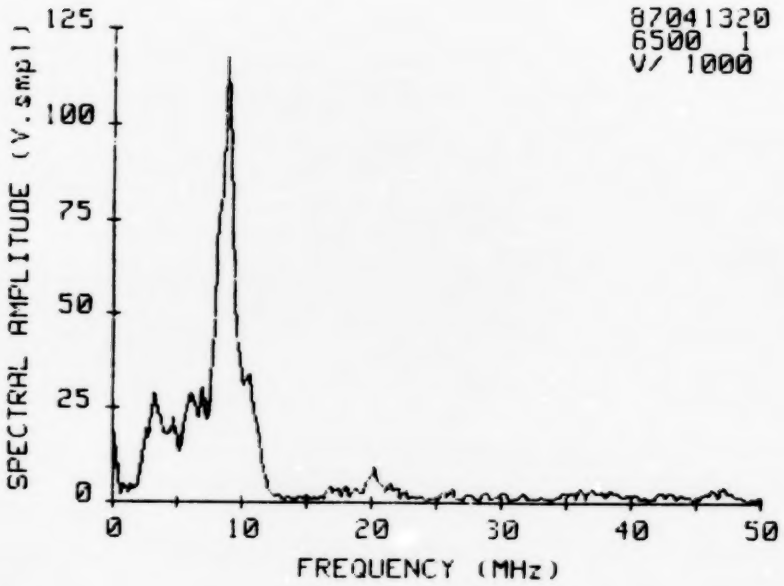


FIGURE 2

VOLTAGE TRANSIENT MEASURED WITH 1000:1 PROBE AT PT TERMINALS DURING OPERATION OF LINE DISCONNECT

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